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A HISTOLOGICAL STUDY OF THE AFFERENT NERVES IN THE STOMACH WHICH ARISE FROM THE POSTERIOR ROOTS OF THE SPINAL CORD.

A. HISTOLOGICAL STUDY OF SENSORY NERVES IN THE STOMACH

by

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I. INTRODUCTION

Many investigators have reported physiological and histological experiments on the sensation of the stomach and they have insisted on its existence.

CHUJI KIMURA (Assist.-Prof. of our clinic) has proved with his acetylcholine method, that sensation in the alimentary canal is innervated by sensory nerves in both the vagus and the sympathetic nerves.

Prof. H. SETO (Tohoku University) has observed sensory nerve endings (SETO) in the esophagus, stomach, duodenum and anus, and he maintains that they are histologically quite different from the autonomic nervous periphery: they terminate in free endings not in a network.

A. Orsu systematically studied the sensory innervation of the stomach by secondary degeneration after section of nerve roots. Thus he proved the existence of vagal afferent nerve fibers, but concerning the afferents arising from the posterior roots of the spinal cord, he could not clearly prove the degenerated figures of nerve fibers in the stomach after posterior rhizotomy. In his experiment he examined the changes in nerves in the stomach 18 days after posterior rhizotomy.

It seems to be too late for observing secondary degeneration after rhizotomy. Furthermore, his description is not clear on what part the rhizotomy was done. According to many authors of our clinic, posterior rhizotomy must be done distal to the spinal ganglia. The author, therefore, tried again to prove by degeneration experiments the afferent nerves in the stomach.

II. MATERIALS AND METHODS

The materials used in this study were the stomachs of dogs and human beings. Only fresh specimens, taken operatively and immediately after resection, were stained. After fixation for 2-3 weeks in 10% neutral formol solution, the specimens were frozen, sliced in thickness of 35-45 μ , fixed again in 10% neutral formol solution for 2-3 weeks, and then stained.

For systematic observations, laminectomy was performed on dogs under general anesthesia with sodium isomytal. The dorsal roots of the spinal cord were cut

distal to spinal ganglia on both sides. In other dogs, unilateral vagotomy was performed in the neck at a point distal to the ganglion nodosum, or bilateral vagotomy was done in the thorax under positive pressure breathing.

Secondary degeneration of nerve fibers was observed by EHRlich's method, while changes in the nervous syncytium and ganglion cells were observed by JABONERO's silver carbonate impregnation.

Operations were performed as follows:

- (1) Section of the dorsal roots on both side (Th_5 - Th_8).
- (2) Section of the dorsal roots on both side (Th_9 - Th_{11}).
- (3) Section of the dorsal roots on both side (Th_{11} - Th_{13}).
- (4) Section of the dorsal roots on both side (L_1 - L_3).
- (5) Cervical vagotomy on the left side at a point distal to the ganglion nodosum.
- (6) Cervical vagotomy on the right side at a point distal to the ganglion nodosum.
- (7) Bilateral vagotomy in the thorax.

III. SYSTEMATIC OBSERVATION OF THE SENSORY INNERVATION OF THE STOMACH

1) Bilateral posterior rhizotomy

According to J. N. LANGLEY, O. FOERSTER, S. W. RANSON, P. R. BILLINGSLEY and others, most of the visceral afferent nerves are myelinated nerve fibers derived from the sympathetic trunk.

D. SHEEHAN has proved that the visceral afferent nerves, which reach sensory endings such as the Vater-Pacinian corpuscles in the mesentery, have their cell bodies in the spinal ganglia of the dorsal roots of the spinal cord.

I examined the degenerated nerve fibers in the stomach following experimental posterior rhizotomy.

The specimens were taken from dogs on which posterior rhizotomy had been performed distal to the ganglia of the dorsal roots. Most of the stomach was resected 5 days after rhizotomy, and stained with EHRlich's hematoxylin method.

Rhizotomy was performed on the segments from Th_5 to L_3 , and the experiments were divided in 4 groups as follows.

- Group 1.....Rhizotomy on Th_5 Th_8
- Group 2.....Rhizotomy on Th_9 Th_{11}
- Group 3.....Rhizotomy on Th_{11} Th_{13}
- Group 4.....Rhizotomy on L_1 L_3

After experimental posterior rhizotomy, myelinated nerve fibers in the stomach were stained unequally, broken at places, and looked like granules or beads. A few degenerated nerve fibers were found in the specimens taken 4 days after rhizotomy. Observation 5 days after operation was most suitable for tracing the degenerated nerves. In the specimens taken more than 6 days after operation, some of the nerves had already disappeared. Degeneration of myelinated nerve fibers was found

frequently in nerve bundles in the submucous and muscular layers.

Group 1. Degenerated nerve fibers were found in the submucous layer of the cardia and the corpus ventriculi. (Fig. 3)

Group 2. Degenerated nerve fibers were found most frequently in the muscular and submucous layer in every part of the stomach. (Fig. 4) (Fig. 5)

Group 3. Degenerated nerve fibers were found in the submucous layer of the corpus ventriculi as well as the pars pylorica. (Fig. 5)

Group 4. A few degenerated nerve fibers were observed in the submucous layer of the pars pylorica. (Fig. 7)

According to the results of these experiments, the afferent nerves of the stomach of dogs are derived from thoracolumbar segments extending from Th₅ to L₅, and most of these nerves run via the greater and smaller splanchnic nerves.

No degeneration of the preterminal or terminal reticulum was found after posterior rhizotomy.

2) Vagotomy.

Many investigators have reported the existence of afferent nerves in the vagus nerve from their physiological studies. A. Otsu found degenerated myelinated nerve fibers in the tunica muscularis and in the tunica submucosa of the pylorus of a dog after vagotomy.

The experiments were divided as follow:

Group 1. Vagotomy on the left side.

Group 2. Vagotomy on the right side.

Group 3. Bilateral vagotomy.

Unilateral vagotomy was performed in the neck at a point distal to the ganglion nodosum. Bilateral vagotomy was performed in the thorax under positive pressure breathing.

In all cases, degeneration of the myelinated nerve fibers in the tunica submucosa was observed in every part of the stomach. (Fig. 8, Fig. 9, Fig. 10)

It was most suitable to observe secondary degeneration of nerve fibers in the stomach 8 days after Vagotomy.

No change was found in the preterminal or terminal reticulum in the stomach after vagotomy.

DISCUSSION

As regard to the peripheral structure of the autonomic nervous system, there are the morphological studies by BOEKE, STÖHR Jr., JABONERO and others. Their observations are similar in that they all describe terminal network structure without free endings.

Ph. STÖHR Jr. called this terminal network "terminal reticulum", which consists of fine nerve fibrils with or without neuroplasmatic syncytia around them. JABONERO, in his own modification of BIELSCHOWSKY's impregnation with silver carbonate, maintains that the terminal autonomic nerve fibrils are without exception surrounded by neuroplasmatic syncytia and he describes arguments against the

terminal reticulum (Stöhr) which has no neuroplasmatic syncytia. So JABONERO called the unit of the peripheral autonomic nervous structure "Nervous Syncytium".

The author cannot decide whether Stöhr's "terminal reticulum" or JABONERO's "nervous syncytia" is the better term to describe the unit of peripheral autonomic nervous structure. However, considering the uncertain differentiation of nervous fibrils from the collagenous or the trelis fibers in the silver impregnated preparations, the usual existence of the neuroplasmatic figures around the neurofibrils in the preparation makes it easy to distinguish the fine nervous substances from other tissues. JABONERO insists upon the existence of a special nerve cell in AUERBACH's plexus which forms a synaptic contact with the postganglionic fibers, exclusively gives rise to the nervous syncytium.

The author found such a special nerve cell (Fig. 2) which supports JABONERO's opinion, but is not certain whether this special sort of the nerve cell alone can be the origin of the nervous syncytium.

As for the nature of the visceral sensory nerves, Sero maintains that there is a special feature which is histologically distinguishable from the autonomic nerves: they are thicker than the autonomic nerve fibers and terminate in free endings.

Orsu, in agreement with Sero's opinion, described the special character of Sero's visceral sensory nerves as consisting of one single neuron between the nerve roots in the spinal ganglia and the effector tissues, and as being myelinated even near their endings.

Orsu studied the sensory nerves in the stomach and tried to determine the sites of their roots in the vagus or in the posterior ganglia of the spinal cord.

He proved secondary degeneration in the mucous membrane of the stomach appearing after section of the vagus trunk distal to the nodular ganglion, but it was not possible to call the changes in the sensory nerves, after section of the posterior roots of the spinal cord Wallerian degeneration. He only described them therefore, as abnormal figures of the nerve fibers.

The author could clearly demonstrate degenerated myelinated fibers and follow them as far as the submucous layer of the stomach.

Why did Orsu fail to observe typical degenerated figures of nerves in the stomach after cutting the posterior roots? He examined too late and the rhizotomy was not performed exactly distal to the spinal ganglia.

Secondary degeneration should be examined 5 days after rhizotomy.

The optimal degeneration figure appears in the posterior rhizotomy cases a few days earlier than the vagotomy case (8 days in the latter).

According to the author's observations, stomach receives its sensory supply from the posterior roots on both sides of the spinal cord between Th. 5 and L. 3, especially from Th. 9 to Th. 11.

This suggests that the gastric sensory nerves have their roots in many segments of the spinal cord spreading out of the focus at Th. 8.

The author supposes that vagal sensory nerves in the stomach somewhat predominant in number over those of the spinal sensory nerves, but it is not

certain, as he could not keep an exact count of these nerve fibers.

V. SUMMARY AND CONCLUSIONS.

- 1) The gastric sensory nerves consist of vagal and spinal nerves.
- 2) The spinal gastric sensory nerves arise from the posterior roots between Th. 5 and L. 3. mainly between Th. 9 and Th. 11. in the dog.
- 3) The optimal Wallerian degeneration features of the gastric sensory nerves can be seen 5 days after posterior rhizotomy and 8 days after vagotomy.
- 4) The vagal gastric sensory nerves seem to be more numerous than the spinal sensory ones.
- 5) The special nerve cell, which exclusively gives rise to the nervous syncytium, was found in the myenteric plexus of the stomach wall.
- 6) The author did not find a special sensory body in the stomach.

I am much indebted to Assist.-Prof. Dr. Ch. KIMURA for his constant help throughout this study.

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和 文 抄 録

脊髄後根に由来する胃の求心性神経に関する組織学的研究

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EHRLICH 氏神経髄鞘染色法を用いて犬の神経幹切断実験を行い胃壁内末梢神経の2次変性を追求し、又 JABONERO 氏鍍銀染色法を人胃に用いて次の如き結果を得た。

- 1) 胃の知覚神経は迷走神経及び脊髄後根を通る。
- 2) 脊髄性胃知覚神経は犬に於てはTh.5よりL.3の間の脊髄後根を通り、Th.9よりTh.11の間を通るものが最も多い。

3) 胃知覚神経の変性像は脊髄後根切断後5日で、迷走神経切断後8日で最も定型的に観察される。

4) 胃に於ては迷走性知覚神経は脊髄性知覚神経より稍優勢である。

5) 神経性 Syncytium の起始細胞が胃壁筋間神経叢に見出された。

6) 胃に於ては特殊な知覚終末体は見出さなかつた。

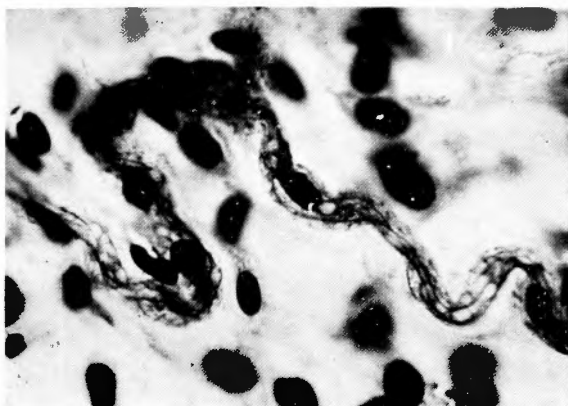


Fig. 1 A nervous syncytium' (JABONERO) in the submucous layer of the stomach. (Dog) J. $\times 1000$

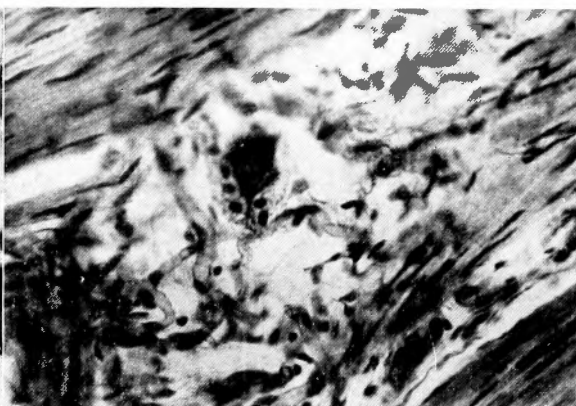


Fig. 2 A nerve cell in the AUERBACH's plexus of man which is described by JABONERO as the origin of the nervous syncytium. J. $\times 1000$

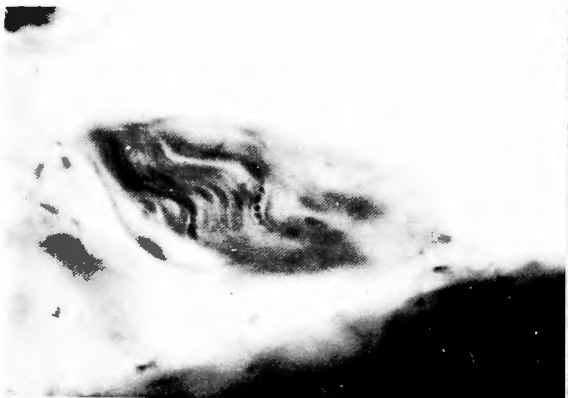


Fig. 3 Degenerated nerve fibers in the submucous layer of the stomach of a dog after posterior rhizotomy. (Th.5- Th.8) E. $\times 400$

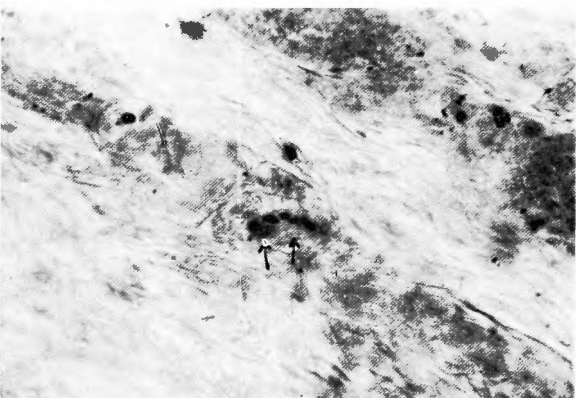


Fig. 4 Degenerated nerve fibers in the submucous layer of the stomach of a dog after posterior rhizotomy. (Th. 9- Th.11) E. $\times 400$



Fig. 5 Degenerated nerve fibers in the muscular layer of the stomach of a dog after posterior rhizotomy (Th.9- Th.11) E. $\times 400$

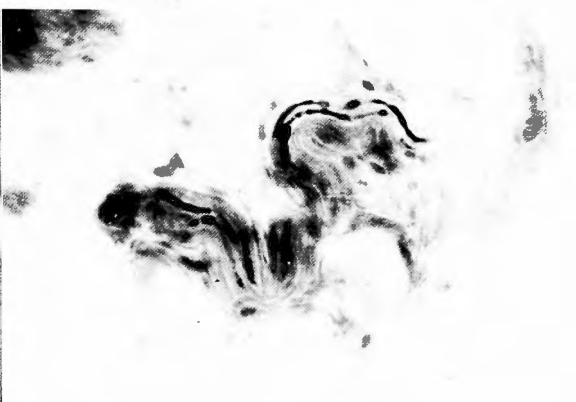


Fig. 6 Degenerated nerve fibers in the submucous layer of the stomach of a dog after posterior rhizotomy. (Th.11 - Th.13) E. $\times 400$

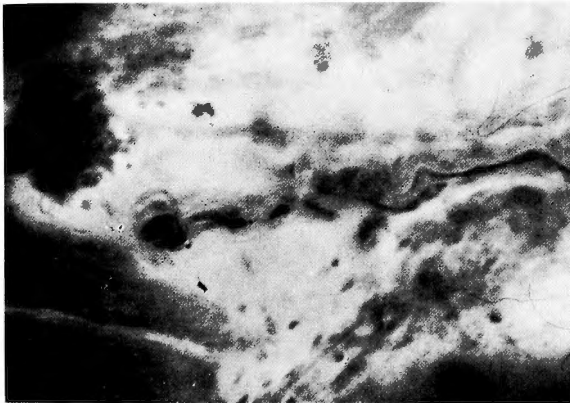


Fig. 7 Degenerated nerve fibers in the submucous layer of the stomach of a dog after posterior rhizotomy. (L1.-L3)
E. $\times 400$

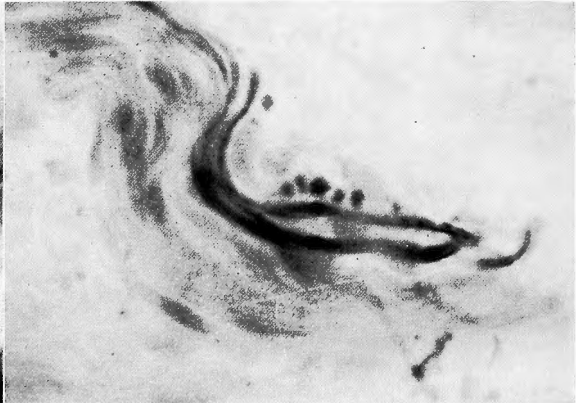


Fig. 8 Degenerated nerve fibers in the submucous layer of the stomach of a dog after vagotomy on the left side.
E. $\times 900$

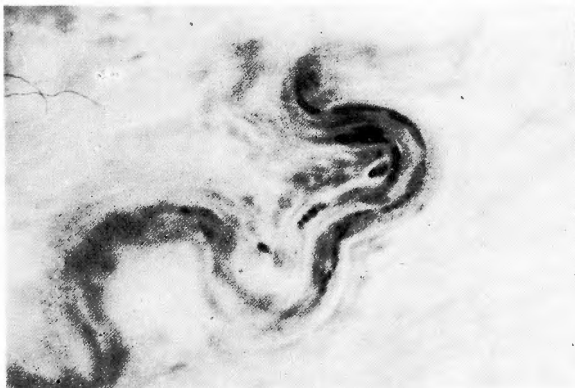


Fig. 9 Degenerated nerve fibers in the submucous layer of the stomach of a dog after vagotomy on the right side.
E. $\times 400$

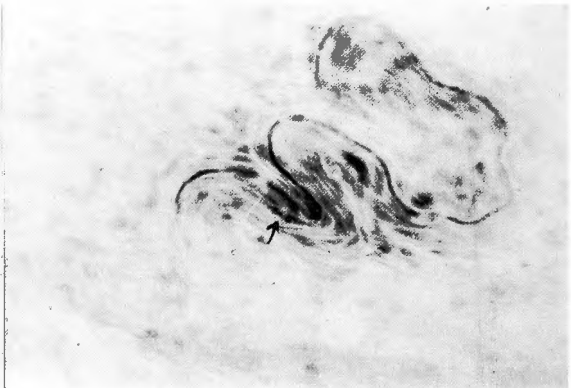


Fig. 10 Degenerated nerve fibers in the submucous layer of the stomach of a dog after bilateral vagotomy. E. $\times 400$

J. JABONERO's method
E. EHRLICH's method